Instructor(s): *Profs. Korytov, Takano*

PHYSICS DEPARTMENT

PHY 2049, Spring 2014 Midterm 2 March 25, 2014

Name (print): _____ Signature: _____

On my honor, I have neither given nor received unauthorized aid on this examination.

YOUR TEST NUMBER IS THE 5-DIGIT NUMBER AT THE TOP OF EACH PAGE.

DIRECTIONS

(1) **Code your test number on your answer sheet (use 76–80 for the 5-digit number)**. Code your name on your answer sheet. **Darken circles completely (errors can occur if too light)**. Code your student number on your answer sheet.
(2) Print your name on this sheet and sign it also.
(3) Do all scratch work anywhere on this exam that you like. At the end of the test, this exam printout is to be turned in. No credit will be given without both answer sheet and printout with scratch work.
(4) Work the questions in any order. Incorrect answers are not taken into account in any way; you may guess at answers you don't know.
(5) If you think that none of the answers is correct, please choose the answer given that is closest to your answer.
(6) **Blacken the circle of your intended answer completely, using a number 2 pencil**. Do not make any stray marks or the answer sheet may not read properly. Completely erase all incorrect answers, or take a new answer sheet.
(7) As an aid to the examiner (and yourself), in case of poorly marked answer sheets, please circle your selected answer on the examination sheet. Please remember, however, that in the case of a disagreement, the answers on the bubble sheet count, NOT what you circle here. Good luck!!!

>>>>>>>>**WHEN YOU FINISH** <<<<<<<<

Hand in the answer sheet separately.

Constants: $e = 1.6 \times 10^{-19}$ C $m_p = 1.67 \times 10^{-27}$ kg $m_e = 9.1 \times 10^{-31}$ kg $\epsilon_o = 8.85 \times 10^{-12}$ C^2/N·m^2

$k = 1/(4\pi\epsilon_o) = 9 \times 10^9$ N·m^2/C^2 $\mu_0 = 4\pi \times 10^{-7}$ T·m/A nano $= 10^{-9}$ micro $= 10^{-6}$

Sphere: $A = 4\pi R^2$ $V = \frac{4\pi}{3}R^3$ pico $= 10^{-12}$

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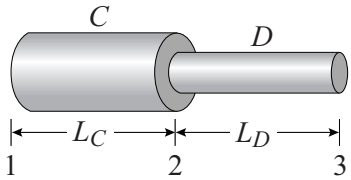
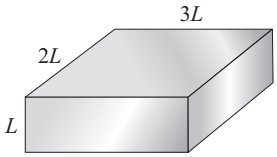
1. Wires C and D, made from different materials and having lengths $L_C = L_D =$ 1 m, are joined together as shown in the figure. The resistivity and radius of wire C are $2 \times 10^{-6}\Omega$·m and 1 mm, and those of wire D are $1 \times 10^{-6}\Omega$·m and 0.5 mm. When a current of 1 A is applied to this combo wire, what is the rate (in W) at which energy is dissipated between points 1 and 2?



(1) 0.64 (2) 0.32 (3) 1.1 (4) 1.8 (5) 2.7

2. The figure shows a rectangular solid conductor of edge lengths L, $2L$, and $3L$. A potential difference V is to be applied uniformly between three pairs of opposite faces of the conductor in three ways. Those pairs are
(a) the left and right faces,
(b) the top and bottom faces,
(c) the front and back faces.
Rank the pairs, greatest first, according to the drift speed of the electrons in the conductor.



(1) $b > c > a$ (2) $a > c > b$ (3) $c > a > b$ (4) $a > b > c$ (5) $a = b = c$

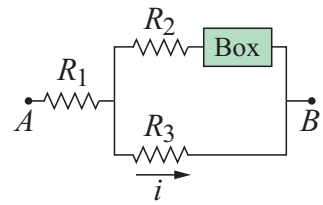
3. A potential difference is applied to each of three copper rods as follows.
(a) Rod A: length L, radius $3R$, potential difference V.
(b) Rod B: length $2L$, radius R, potential difference $2V$.
(c) Rod C: length $3L$, radius $2R$, potential difference $2V$.
Rank the rods, greatest first, according to the magnitude of the electric field within them.

(1) $A = B > C$ (2) $B = C > A$ (3) $A > B > C$ (4) $C > B > A$ (5) $C > A > B$

4. A particular wire has a circular cross section. For the first 0.5 m of its 1 m length, its radius is 4 mm, whereas for the second half it is 2 mm. 14 coulombs of charge pass a point in the 4 mm section in 30 seconds. The current in the 2 mm section is:

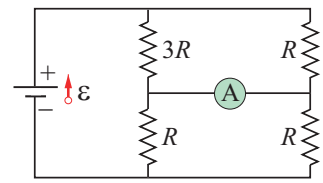
(1) 467 mA (2) 933 mA (3) 233 mA (4) 117 mA (5) need the resistivity to solve.

5. The figure shows a section of a circuit, in which the resistances are $R_1 = 1\,\Omega$, $R_2 = 2\,\Omega$, and $R_3 = 3\,\Omega$. When an electrical potential difference of 78 V is applied between points A and B, the indicated current in the figure is $i = 12$ A. Which of the following statements about the "Box" in the figure is correct?



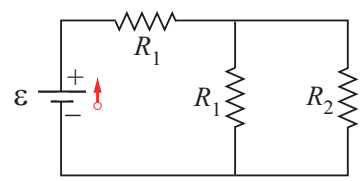
(1) It is a 24 V battery.
(2) It is a $1\,\Omega$ resistor.
(3) It is a 36 V battery.
(4) It is a $5.5\,\Omega$ resistor.
(5) It is a piece of wire.

6. What is the current through the ammeter A? Assume that the ammeter is ideal, meaning it has zero resistance.



(1) $\mathcal{E}/(5R)$
(2) $7\mathcal{E}/(4R)$
(3) $2\mathcal{E}/(3R)$
(4) 0
(5) infinite

7. In the circuit shown, $\mathcal{E} = 12\ V$, $R_1 = 16\ \Omega$, and R_2 is variable. If the value of R_2 is chosen so that the ideal battery will transfer energy to the resistors at the maximum possible rate, what is that rate (in watts)?



(1) 9 (2) 3 (3) 6 (4) 4.5 (5) 12

8. A 1 MΩ resistor and a 15 μF capacitor are connected in series with an ideal battery of emf $\mathcal{E} = 6.0$ V. At $t = 2$ s after the connection is made, what is the rate at which the charge of the capacitor is increasing (in amperes)?

(1) 5.3×10^{-6} (2) 7.9×10^{-5} (3) 2.7×10^{-5} (4) 8.4×10^{-6} (5) 2.1×10^{-6}

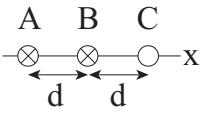
9. A proton travels through uniform magnetic and electric fields. The magnetic field is $\vec{B} = -3\hat{\imath}$ mT, and the electric field is $\vec{E} = 4\hat{k}$ V/m. At one instant the velocity of the proton is $\vec{v} = 2\hat{\jmath}$ km/s. At that instant, what is the net force acting on it?

(1) $1.6 \times 10^{-18}\hat{k}$ N (2) $-3.2 \times 10^{-19}\hat{k}$ N (3) $-1.6 \times 10^{-18}\hat{k}$ N (4) $3.2 \times 10^{-18}\hat{k}$ N (5) 0

10. An electron with a kinetic energy of 2.0 keV is projected into a uniform magnetic field of 0.1 T, with its velocity vector making an angle of 70° with the field. What is the pitch of its helical path (in meters)?

(1) 3.2×10^{-3} (2) 5.7×10^{-3} (3) 7.1×10^{-3} (4) 1.4×10^{-3} (5) 8.3×10^{-4}

11. Three wires lie along the x axis (perpendicular to the page) as shown. Wires A and B each carry current I into the page. When wire C carries no current, wire B experiences a force F. With no other currents changed, in order for wire B to experience a force $3F$ in the same direction as the original F, the current in wire C must be made:

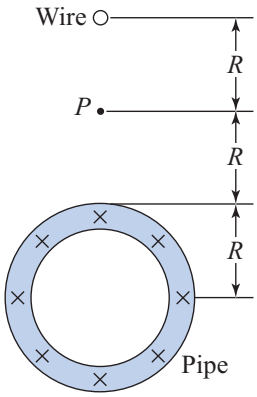


(1) $2I$, out (2) $3I$, out (3) $3I$, in (4) I, in (5) $I/4$, out

12. The magnetic torque exerted on a flat current-carrying loop of wire by a uniform upward magnetic field $\vec{B}$ is maxium when:

(1) the plane of the loop is parallel to $\vec{B}$.
(2) the plane of the loop is perpendicular to $\vec{B}$, with the current in the loop producing a downward field at its center.
(3) the plane of the loop is perpendicular to $\vec{B}$, with the current in the loop producing an upward field at its center.
(4) the plane of the loop makes an angle of 45° with $\vec{B}$.
(5) the plane of the loop makes an angle of 60° with $\vec{B}$.

13. A long circular pipe with outside radius $R = 3$ cm carries a uniformly distributed current 10 mA into the page. A wire runs parallel to the pipe at a distance of $3R$ from center to center. The net magnetic field at point P has the same magnitude as the net magnetic field at the center of the pipe but is in the opposite direction. What is the magnitude of the current in the wire?

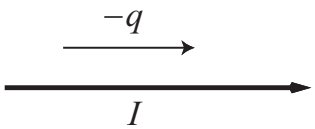


(1) 3.75 mA
(2) 5 mA
(3) 7.5 mA
(4) 9.25 mA
(5) 0

14. A long solenoid with 10 turns/cm and a radius of 10 cm carries a current of 20 mA. A current of 6 A exists in a straight conductor located along the central axis of the solenoid. At what radial distance (in cm) from the axis will the direction of the resulting magnetic field be at 45° to the axis direction?

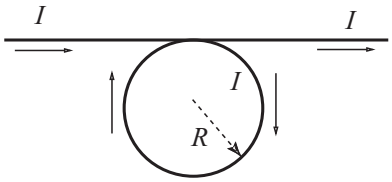
(1) 4.8 (2) 9.1 (3) 2.7 (4) 1.1 (5) 0.85

15. A negatively charged particle moves parallel to a wire carrying an electric current as shown in the figure. In which direction is the magnetic force on the particle?



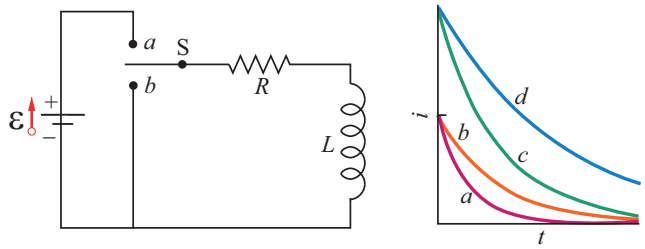
(1) upward (2) downward (3) into the page (4) out of the page (5) leftward

16. An infinitely long insulated wire carrying a current I is bent into the shape shown (straight line plus circle of radius R with the currents in the direction shown). The magnitude of the magnetic field B at the center of the circle is:



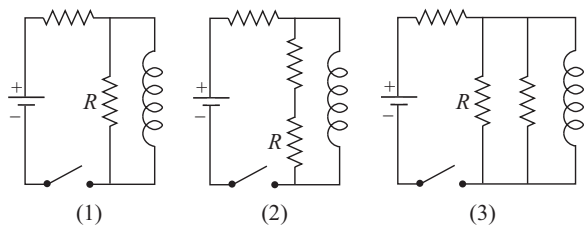
(1) $\frac{(\pi+1)\mu_0}{2\pi}\frac{I}{R}$ (2) $\frac{(\pi-1)\mu_0}{2\pi}\frac{I}{R}$ (3) $\frac{3\mu_0}{4\pi}\frac{I}{R}$ (4) $\frac{\mu_0}{2\pi}\frac{I}{R}$ (5) 0

17. The switch in the circuit shown in the figure is closed on a for a long time, then at time $t = 0$, the switch is thrown instantaneously to b. Curve c in the figure to the right shows the current through the inductor as a function of time. If both resistance R and inductance L were doubled and the switching sequence repeated, which of the curves shown on the graph would represent the current in the inductor?



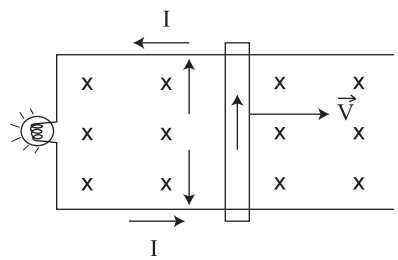
(1) b (2) a (3) c (4) d (5) All four are possible.

18. The figure shows three circuits with identical batteries, inductors, and resistors. The switch is closed for a long time, then opened. Rank the circuits, greatest first, according to the current through the resistor labeled R, just after the switch is opened.



(1) (Circuit 1) = (circuit 2) > (circuit 3).
(2) (Circuit 3) > (circuit 1) > (circuit 2).
(3) (Circuit 1) > (circuit 2) = (circuit 3).
(4) (Circuit 2) > (circuit 1) > (circuit 3).
(5) No current flows through R in any of the circuits.

19. The rod in the figure is moving at a speed of 5.0 m/s in a direction perpendicular to a 0.80 tesla magnetic field, which is directed into the paper. The rod has a length of 1.6 m and has negligible electrical resistance. The rails also have negligible resistance, and the light bulb has a resistance of 96 Ω. Find the induced current in the circuit.



(1) 0.067 A (2) 26 A (3) 614 A (4) 0.43 A (5) 6.4 A

20. A 10 H inductor is connected in series with a resistor and a 20 volt battery. After the current reaches its maximum value, the energy stored in the magnetic field of the inductor is 80 J. The resistance of the circuit (in ohms) is:

(1) 5.0 (2) 10.0 (3) 2.83 (4) 2.25 (5) none of these